Investigation

BLOWING IN THE WIND

Background Information

Air-quality standards are set by the federal government and monitored in Texas by the Texas Natural Resource Conservation Commission. Areas that do not meet the standards face consequences such as loss of federal highway funds, stricter permitting rules for industry, and stricter emissions tests for motor vehicles.

The National Ambient Air Quality Standards

POLLUTANT	STANDARD VALUE
Carbon monoxide (CO)	
8-hour average	9 ppm
Ozone (O_3)	
1-hour average	0.12 ppm
Nitrogen dioxide (NO_2)	
Annual arithmetic mean	0.053 ppm
Sulfur dioxide (SO_2)	
Annual arithmetic mean	0.03 ppm
Lead (Pb)	
Quarterly average	1.5 µg/m3
Particulates <10 micrometers	
Annual arithmetic mean	50 µg/m3

- This is a partial list of National Ambient Air Quality Standards. A complete list can be found on the U.S. Environmental Protection Agency's web site at **http://www.epa.gov/airs/criteria.html** .

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Pollutants in the air can be identified by using a gas chromatograph. A gas chromatograph is an instrument that separates the compounds present in a mixture such as air, allowing them to be identified and quantified.

How a GC works. In a gas chromatograph, a sample of the mixture to be analyzed is injected into a stream of inert gas (e.g., helium) flowing through a long column. The column is coiled inside a temperature-controlled oven. The carrier gas moves different chemicals through the column at different rates, the fastest exiting first. As each compound exits the column, the chromatograph's detector plots the size of the electrical signal it generates against the amount of time it spent in the column. The resulting graph (chromatogram) shows what was in the original sample.

To simulate this process, you will create a sample mixture and evaluate its different components. The model will simulate the components of a sample of air, including normal gases such as nitrogen, oxygen and water vapor, as well as pollutants such as ozone, sulfur dioxide, carbon monoxide, nitrogen oxides, lead and particulate matter.

Problem *(fill in problem):* ______________________________

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Materials

hole puncher
map pencils
plastic bag
7 half-sheets of different colors of construction paper
tablespoon

Procedure

1. Punch as many holes as possible out of each half-sheet of construction paper.
2. Place all the different colored spots in the Ziploc bag and mix them up.
3. Using the spoon, scoop out a sample mixture from the bag.
4. Separate the spots into groups by color.
5. Determine which color will represent each component in the air sample and record on the data table.
6. Count the number of spots you have of each color and record on the data table.
7. Let each spot represent 0 .10 parts per million (ppm), except for the spots that represent lead

and particulate matter. Let each lead and particulate-matter spot represent 1.0 micrograms per cubic meter (μg/m3). Determine the quantity each spot represents and record on the data table. Record values on the data table.

8. Repeat steps 3-7 two more times.

Observations

Trial	Color	Representing Component	No. of spots	Value in ppm	Value in μg/m3
1		ozone			NA
2					NA
3					NA
1		sulfur dioxide			NA
2					NA
3					NA
1		carbon monoxide			NA
2					NA
3					NA
1		nitrogen oxides			NA
2					NA
3					NA
1		lead		NA	
2				NA	
3				NA	
1		particulate matter		NA	
2				NA	
3				NA	
1		normal components			NA
2					NA
3					NA

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Create two graphs, one for lead and particulate matter and the other for the remaining pollutants. Make sure you title each graph, label the axes with the units of measure, and create a color key.

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Conclusion

1. Using the NAAQS level table in the background information, determine if any of the components in the "air" samples taken are above acceptable levels. ____________________

2. What are the shortcomings of this simulation? ____________________

3. How could the simulation be improved? ____________________

Application

1. Based on what you know from reading about how ozone forms, why are ozone concentrations generally higher during the day than at night? ____________________

2. Based on what you know from reading about how ozone forms, during what season would you expect ozone levels to peak?____________________

3. Our air knows no boundaries. Wind can carry pollutants hundreds of miles from their origin. The distance air pollutants travel depends on how high in the atmosphere they go. Why does this present a problem?

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4. The Texas Natural Resource Conservation Commission consistently monitors air quality at approximately 150 stations across Texas. Since pollutants travel with the wind, why is it important to monitor so many locations? ______________________________________

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Going Further

5. Air at ground level is usually warmer than air at higher altitudes. This is due to the difference in atmospheric pressure. There is less pressure at higher altitudes, so the molecules in the air can spread out. They collide less often and produce less heat. When a temperature inversion occurs, this process is disrupted. A layer of warm air becomes sandwiched between layers of cooler air above and below because of differences in the density of the layers. Temperature inversions can form near the ground or at heights of hundreds or thousands of feet. In either case, the cooler, denser air layer at the surface is held in place by the warmer, less dense air above. How would a temperature inversion affect air pollution in an area? ______________________________________

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